

Developing a spec for fake track rates in sPHENIX

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Tracking performance criteria

We have recently decided to adopt a set of criteria for tracking performance that can be applied to all combinations of our 4 tracking detector options - **in progress**

Physics Channel	Physics requirements	Momentum resolution	DCA resolution	eID h rejection	Single track off.	Fake track rate
Y-> ee	$\Delta M = 100 \text{ MeV}$ $A\varepsilon = 50\%$ of geom. acceptance	$\Delta p_T < 1.2\%$ (1-8 GeV/c)	N/A	> 90	90% (>2 GeV/c) ?	x% (before CEMC) y% (after CEMC)
D'(z)/D(z)	$\sigma^h/\sigma^{\text{jet}} = x\%$ z = 0-0.8	$\Delta p_T < 4\%$ (1-40 GeV/c)	N/A	N/A ?	x% high pT y% low pT	x% within jet y% overall
b-jet ID via track counting	35% purity at 45% efficiency	?	< 70 μm	N/A	x% (set by 35% @ 45% goal)	y% (set by 35% @ 45% goal)
b-jet ID via secondary vertex	35% purity at 45% efficiency	?	< 70 $\mu\text{m}/(2-3?)$	N/A	90% (>2 GeV/c) ?	y% overall
$\gamma+h$ jet + h	h p_T below jet reco threshold	?	N/A	N/A	90% (>2 GeV/c) ?	y% overall pT dependent
Particle flow jets	?	?	N/A	N/A	90% (>2 GeV/c) ?	y% overall pT dependent

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Developing a spec for fake track rate

It has become critical for sPHENIX to develop **physics driven specifications** for fake track rates, since these will be a major factor driving the configuration of the tracker.

The fake track rate specification will, in general, be different for different physics topics. Therefore we need a fake track spec for:

- Upsilon physics

- Jet fragmentation functions

- Jet substructure studies

- B-jet physics via multiple large DCA tracks

- B-jet physics via secondary vertex reconstruction

- B-jet physics via semileptonic decay tagging

- D-meson reconstruction using unidentified charged tracks

Where this is not intended to be an exhaustive list (and in any case we should expect the list of physics topics to grow as the collaboration does).

Realism is important for this

The silicon tracking macros and code have been modified to add some realism to simulation studies:

- Dead pixels and strips
- Ganging together of strips in the outer tracker as required in the design
 - Gang three strips in the S1a and S1b layers
 - Gang six strips in the S2 layer

The silicon tracking is all still done in cylinder cell geometry, but until the configuration stabilizes that is OK, as long as our material budgets are realistic.

The next step is to make changes to the ghost rejection to better handle the ganged strips. A volunteer to do this would be great!

After the ghost rejection is optimized, the next step will be to study fake rates by physics topic.

Strategy

The general strategy is to make a dedicated fast simulation for each physics topic in which the fake track rate can be specified as input.

Starting with zero fake tracks, increase the fake track rate until it has a significant effect on the physics topic (e.g. signal/background drops significantly).

Make that the fake track rate spec for that physics result.

Fiddle with the tracker configuration until the fake track rate meets that spec.

Then push the detector to more and more realism.

As we add new physics topics, we add new dedicated fast simulations for them.

Some examples in the following slides

B-tagged jets via multiple large DCA tracks

Run central Hijing events for a perfect detector

Get the DCA distribution for all tracks

High DCA values come from fake tracks

Parameterize the DCA distribution from fake tracks to make a background DCA distribution

Make a signal DCA distribution from singles simulations

Normalize background DCA distribution to signal using signal/event rate

Extract the jet purity using a MC sampling the DCA distribution

Try a range of fake track rates by scaling the normalization of the background DCA distribution

When do we fall below our jet purity spec? That sets the fake track rate spec.

B-tagged jets via secondary vertex reconstruction

Run central HIJING events for a perfect detector

Get DCA distribution for all tracks

Parameterize DCA distribution from fake tracks to make background DCA distribution

Make the signal DCA distribution for tracks forming secondary vertices

Normalize background DCA distribution to signal DCA distribution using signal/event rate

Extract the secondary vertex fake rate using MC sampling of the DCA distribution

Derive the jet purity

Try a range of fake rates by scaling the normalization of the background DCA distribution.

When does the purity fall below our spec for this measurement? That sets the fake track rate spec.

D mesons

Run central HIJING events for perfect detector, reconstruct all tracks

Get the background mass spectrum shape for all charged track pairs: assume π -K then K- π masses

Make signal mass spectrum for D decays (correct masses + opposite masses)

Normalize background to signal counts using signal/event rate

Vary the background mass spectrum by scaling by $(\text{fake} * (1 + \text{fake}/\text{real})^2)$

Derive p_T (of D) dependent spec for fake/real from S/B in mass spectrum

Derive from that the p_T dependence of the hadron spec for fake/real

Fragmentation Functions

This needs thought

We decided to ask Dennis Perepelitsa to figure it out!